

Aus dem Roentgeninstitut
(Leiter: PD Dr. med. H. J. KAUFMANN)
des Kinderspitals der Universität Basel
(Direktor: Prof. Dr. med. A. HOTTINGER)

**Roentgen-Study of the Development
of the Frontal Sinus and the Interorbital Distance in the
Half-Axial View During Infancy and Childhood**

Inaugural-Dissertation
zur Erlangung der Doktorwürde der gesamten Heilkunde
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GERALD N. SIEDBAND

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S. KARGER

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A recent increase in the incidence of frontal sinusitis in young children was noted at the Basel Kinderspital. Diagnosis was established by clinical symptomatology and also by roentgenogram. The question therefore was raised as to when the frontal sinuses are sufficiently developed to potentially become a clinical entity.

There is considerable disagreement amongst authors regarding the age of onset of the development of the frontal sinuses. The majority of authors agree that these sinuses can be demonstrated by X-ray with some degree of consistency at about eight years of age (1, 2).

In the newborn, the ethmoids are fully pneumatized. Each frontal sinus develops from an anterior ethmoid cell. They begin to ascend into the vertical portion of the frontal bone during the second year. When this invasion of the frontal bone and pneumatization are sufficiently advanced the sinuses are demonstrable during the first two to four years of life (3). The frontal sinuses average about 3.8 mm above the nasation at three years, and

continue to ascend at an approximate rate of 1.5 mm per year until the fifteenth year when they are more or less mature (4). When there is severe ethmoid disease in the first few years of life, the development and pneumatization of the frontal sinuses may be curtailed or even completely prevented (3). Normally there is symmetrical growth in the developing child, but in the development of the frontal sinuses asymmetry of form is the rule rather than the exception (5, 6).

In a review of over eight hundred roentgenograms of children from the files of the X-ray department of the Basel Kinderspital, a survey was made to determine at what age and to what extent the frontal sinuses are present. At the same time, the interorbital distances were measured to investigate how the results obtained, using the half-axial projection (or Waters view), compared with those of Currarino and Silverman, who utilized the posterior-anterior roentgen projection in their survey of two hundred and fifty children (3, 7). It is thus the purpose of this study to attempt to answer these two questions: 1. At what age are the frontal sinuses sufficiently developed to become a clinical entity? 2. What is the normal interorbital distance in this projection?

Material and Methods

807 skull roentgenograms were reviewed. The range of age is from birth to fifteen years. The breakdown of the age groups is given in Table I. The children were placed brow-down on a 'Schonander Table' and the skull centered on a special scale, for the half-axial or Waters view. The target-tabletop distance was 90 cm. Time and dosage varied with the age of the child. The range was from 0.03 seconds at 80 kilovolts to 0.08 seconds at 88 kilovolts. Kodak Royal Blue Film with a detail screen and a Bucky diaphragm were utilized. For the measurements of the skull roentgenograms, a viewing screen and a rule, calibrated in millimeters, were used. The points of reference were as follows:

1. The widest point of the frontal sinus in the frontal bone.
 2. The length of the individual sinus is from the highest point—on each side of the septum—in the frontal bone to the point of intersection with the interorbital distance measurement.
 3. The interorbital distance is between the medial walls of the orbit at approximately the level of the junction between each medial angular process of the frontal bone with the maxillary and lacrimal bones. See figure 4 a.
- Neither sex of child nor reason for the roentgenogram were taken into consideration. The first fifty roentgenograms of different children (or as many as could be found) for their respective age groups were utilized.

TABLE I

Group	From	To	No. of films
1	0	12 months	50
2	13	18 months	50
3	19	24 months	50
4	25	36 months	50
5	37	48 months	50
6	49	60 months	50
7	61	72 months	50
8	73	84 months	50
9	85	96 months	50
10	97	108 months	50
11	109	120 months	50
12	121	132 months	50
13	133	144 months	50
14	145	156 months	50
15	157	168 months	50
16	169	180 months	32
17	181	192 months	25

Analysis of Findings

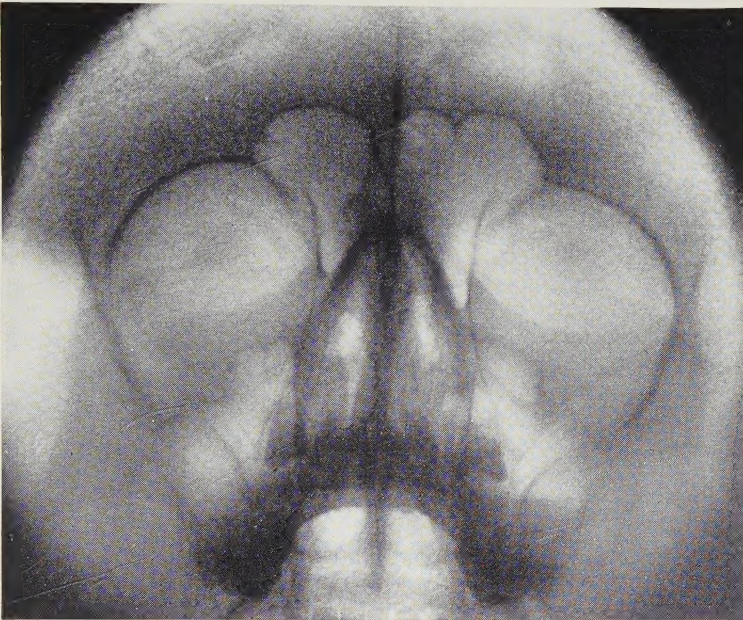
Frontal Sinuses

Figures 1 to 4 are photos of roentgenograms of four different age groups chosen at random, four (Fig. 1), six (Fig. 2), ten (Fig. 3) and fourteen years of age (Fig. 4), to demonstrate the extremes which are prevalent in the development of the frontal sinuses. One set of examples, Figures 1a, 2a, 3a, 4a, demonstrate well-developed pneumatized frontal sinuses. The other set of examples, Figures 1b, 2b, 3b, and 4b demonstrate either the lack of development of the frontal sinuses, or their presence, but only to a slight degree.

Table II is a composite of the frontal sinus measurements. The high and low, as well as the median values are depicted. Wilson, utilized the nasation as his point of reference in measuring the length of the frontal sinuses. The author utilized a point approximately 1 to 2.5 cm (depending on the age of the child) below the nasation. This point was measured from the highest point in the frontal bone—on each side of the septum—to a line at approximately the level of the junction between each medial angular process of the frontal bone with the maxillary and lacrimal bones. The results obtained in this survey are comparable to the rate of growth as stated by Wilson.

TABLE II

Age Group	Widest point of frontal sinus in cm.			Length of individual frontal sinus in cm.			
	High	Low	Median values		High	Low	Median values
1	2.4	1.35	1.90	R	1.0	0.0	0.04
				L	1.5	0.0	0.05
2	2.6	1.4	1.92	R	1.5	0.0	0.19
				L	1.5	0.0	0.21
3	2.4	1.55	1.97	R	1.5	0.0	0.21
				L	1.3	0.0	0.22
4	2.7	1.5	1.99	R	2.0	0.0	0.61
				L	1.8	0.0	0.62
5	3.2	1.7	2.23	R	2.3	0.0	1.06
				L	2.3	0.0	0.92
6	4.8	1.7	2.55	R	2.9	0.0	1.39
				L	3.8	0.0	1.47
7	5.2	1.95	2.66	R	3.1	0.0	1.68
				L	3.7	0.0	1.84
8	5.7	2.0	3.00	R	3.6	0.3	2.00
				L	4.1	0.0	2.22
9	5.7	2.1	3.09	R	3.6	0.3	1.98
				L	4.6	0.4	2.14
10	9.3	2.3	3.68	R	4.2	0.0	2.31
				L	4.3	0.0	2.63
11	7.9	2.3	3.97	R	4.7	0.0	2.48
				L	5.0	0.7	2.73
12	7.4	2.4	4.40	R	4.4	0.3	2.80
				L	5.0	0.4	3.12
13	8.2	2.0	4.77	R	5.0	0.0	3.11
				L	4.8	0.0	3.25
14	8.1	2.6	4.77	R	5.0	0.0	3.00
				L	5.8	0.6	3.33
15	9.4	2.1	4.71	R	5.0	0.5	2.91
				L	6.0	0.4	3.10
16	9.0	3.2	5.67	R	5.4	2.0	3.71
				L	5.2	1.6	3.60
17	9.2	3.2	5.66	R	6.0	2.3	3.67
				L	5.9	0.6	3.76



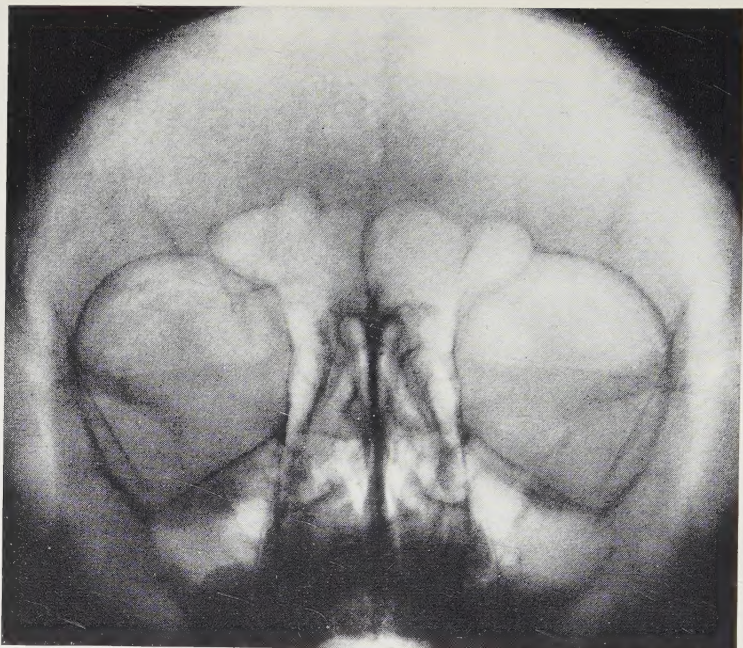
1a



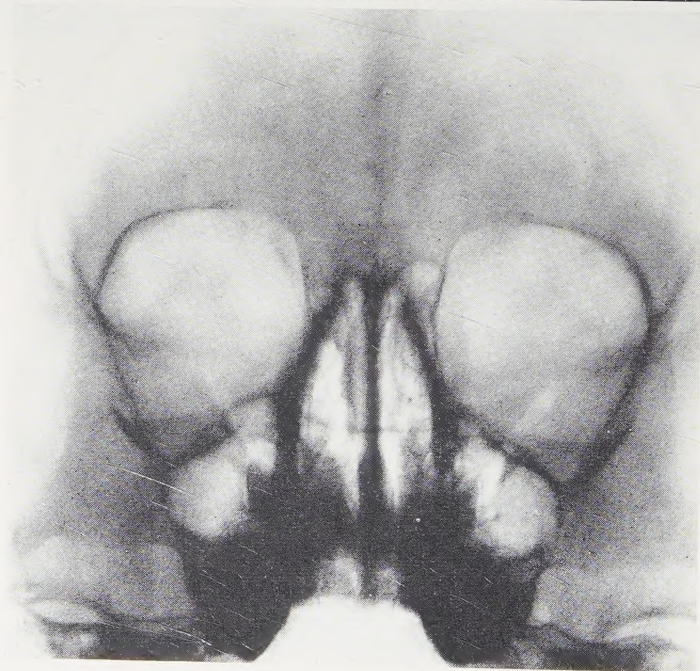
1b

Fig. 1 a. Skull roentgenogram of a four-year-old child. This film demonstrates that the frontal sinuses can be developed to a very marked degree at this early age.

Fig. 1 b. Skull roentgenogram of a four-year-old child. No pneumatization of the frontal sinus is noticeable.



2a



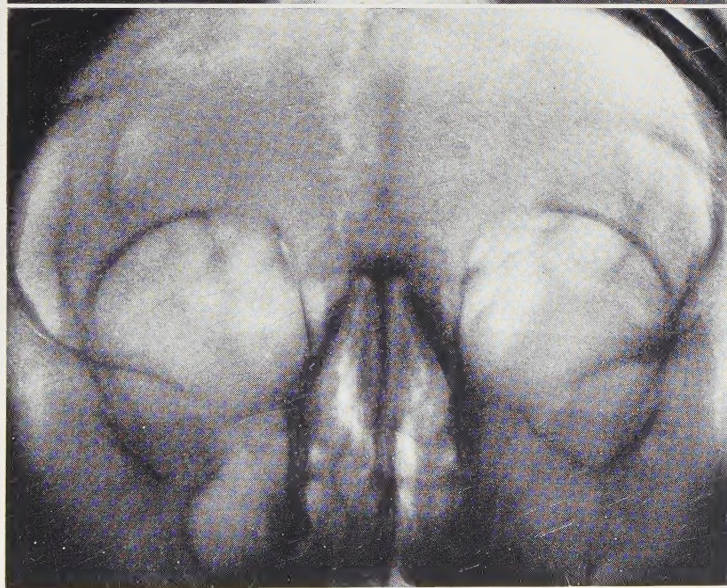
2b

Fig. 2 a. Skull roentgenogram of a six-year-old child. Beside the advanced development of the frontal sinuses, there is also an unusually good pneumatization of the ethmoid cells.

Fig. 2 b. Skull roentgenogram of a six-year-old child, with lack of development of the frontal sinuses.



3a



3b

Fig. 3 a. Skull roentgenogram of a ten-year-old child, with an almost 'adult type' of pneumatization of the frontal sinuses.

Fig. 3 b. Skull roentgenogram of a ten-year-old child. This child with evidence of chronic pan-sinusitis, displays no evidence of any development of the frontal sinuses.

Table III is a graphic representation of the interorbital distances obtained. The average interorbital distance varies according to the age. The difference between the high and low values per age group average about 1 cm, with a high value of 1.3 and a low of 0.8 cm. The median value rises slowly, but not in a precise progression. The results obtained in this work compare closely with those of *Currarino and Silverman*, though the author employed the half-axial (Waters view) projection, whereas *Currarino and Silverman* used the posterior-anterior projection.

TABLE III

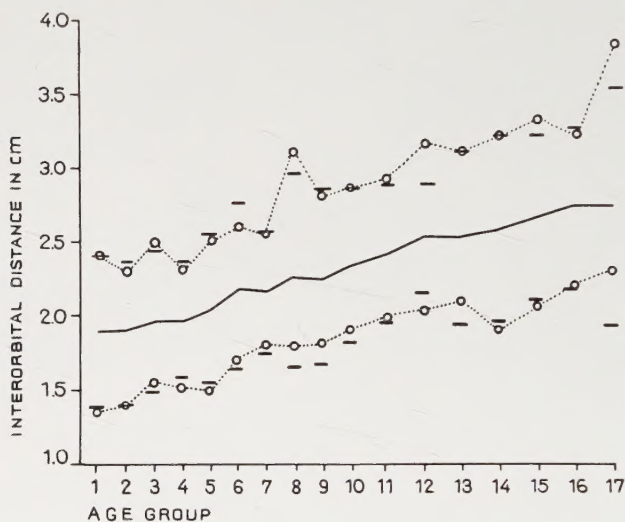


Table III. Measurements of the interorbital distance obtained from 807 skull roentgenograms chosen at random ranging in age from birth to fifteen years of age. The uninterrupted line unites the calculated mean of the values obtained from each age group; the broken lines connecting the circles are the high and low values of these age groups. The solid broken line represents 2.5 standard deviation above and below the mean and comprises 98.2 per cent of all measurements.

Fig. 4 a. Skull roentgenogram of a fourteen-year-old child. The white dots indicate the points chosen to measure the width and length of the frontal sinuses, and the points chosen to measure the interorbital distance in this study. This is a representation of the complete adult type of pneumatization.

Fig. 4 b. Skull roentgenogram of a fourteen-year-old child, with minimal development of the frontal sinuses.



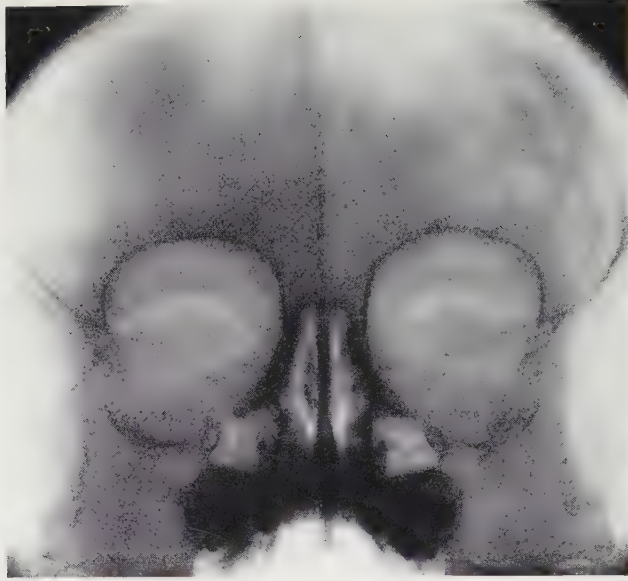


Fig. 5. Half-axial roentgenogram of the skull of a nineteen-month-old child with Trigonocephaly and hypotelorism. The interorbital distance of this case is 1.35 cm.

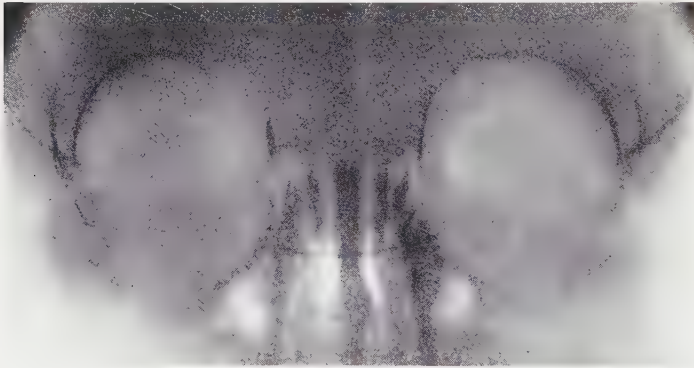


Fig. 6. Half-axial roentgenogram of the skull of a ten-month-old child with hypertelorism. The interorbital distance of this case is 2.50 cm.

To ascertain the validity of the obtained results, two cases from two different age groups (see Figs. 5 and 6) were further investigated. Their interorbital distance fell well outside the 2.5 standard deviation above and below the mean (this comprised 98.2

per cent of the normal). It was verified from their cases histories that one patient had hypotelorism (trigonocephaly), and the other patient had hypertelorism.

Conclusions

From the material studied and presented it can be concluded that pneumatization of the frontal sinuses can be present to such an extent that clinically the manifestation of frontal sinusitis has to be considered as a distinct possibility in children as young as three years of age.

As a collateral of this study, the determination of the interorbital distances for the evaluation of hypo- or hypertelorism can be preformed on the half-axial (Waters view) just as well as on the posterior-anterior view. The actual measurements correlate closely enough so that both curves can be used interchangeably.

Summary

Based on a random review of 807 half-axial projections, covering the entire pediatric age range, from the X-ray files of the Basel Kinderspital, the following problems were investigated:

1. At what age level is pneumatization of the frontal sinuses such, that the possibility of frontal sinusitis must theoretically be considered?
2. The applicability of the half-axial (Waters view) projection, as a diagnostic tool in determining cases of hypo- or hypertelorism.

This study leads to the following conclusions:

1. Frontal sinusitis can be expected to occur as of the third year of life —based on the degree of pneumatization established in this survey of films taken at the Basel Kinderspital during the years 1961 to 1964.
2. The interorbital distance appears to be a valid tool in the diagnosis of hypo- and hypertelorism. Values obtained in the half-axial projection are comparable to the measurements obtained in the posterior-anterior projection and equally applicable.

Zusammenfassung

Auf Grund von 807 Halbbaxialaufnahmen von Kindern jedes Alters aus dem Basler Kinderspital wurden folgende Probleme untersucht:

1. In welchem Durchschnittsalter ist die Pneumatisation des Frontalsinus derart, daß mit der Möglichkeit einer Frontalsinusitis theoretisch gerechnet werden kann?
2. Die Anwendbarkeit der halbbaxialen Schädelaufnahme (Waters-Übersicht) als eine diagnostische Möglichkeit zur Feststellung eines Hypo- oder Hypertelorismus.

Die Studie zeitigte folgende Ergebnisse:

1. Basierend auf den Grad der Pneumatisation kann mit einer Sinusitis der Stirnhöhlen erst vom dritten Lebensjahr an gerechnet werden. Die Auswertung bezieht sich auf die Beurteilung von Röntgenfilmen aus dem Basler Kinderspital unter Berücksichtigung der Jahre 1961 bis 1964.

2. Der interorbitale Abstand kann aus solchen Röntgenbildern gemessen werden und ist eine wertvolle Hilfe für die Diagnose des Hypo- und Hypertelorismus. Die aus diesen halbaxialen Aufnahmen erhobenen Meßwerte sind vergleichbar mit denjenigen, wie sie bei den Posterior-Anterior-Aufnahmen bestimmt werden können und in gleicher Weise verwertbar.

Résumé

Les problèmes suivants ont été étudiés sur la base d'une revue globale de 807 incidences semi-axiales, couvrant toute la gamme d'âge intéressant la pédiatrie et provenant des dossiers radiologiques de la Clinique Infantile de Bâle :

1^o A quel âge la pneumatisation des sinus frontaux est-elle suffisante pour que la possibilité d'une sinusite frontale puisse être théoriquement envisagée ?

2^o L'application de l'incidence semi-axiale (incidence de Waters) comme moyen de diagnostic des cas d'hypo- ou d'hypertelorisme.

Cette étude a amené aux conclusions suivantes :

1^o D'après les radiographies faites à la Clinique Infantile de Bâle entre 1961 et 1964 et se basant sur le degré de pneumatisation, une sinusite frontale peut survenir dès la 3^e année de la vie.

2^o La distance interorbitaire apparaît comme un moyen valable de diagnostic d'hypo- et d'hypertelorisme. Les valeurs obtenues avec l'incidence semi-axiale sont comparables à celles tirées de l'incidence antéro-postérieure ; elles sont également utilisables.

Resumen

Basándose en una revisión de 807 proyecciones medio-axiales seleccionadas al azar, de todas las edades infantiles y procedentes de los archivos de la Clínica Pediátrica de Basilea, se han investigados los siguientes problemas:

1. ¿ A que edad tiene lugar la suficiente neumatización de los senos frontales para que pueda ser considerada teóricamente posible la inflamación sinusal?

2. La posibilidad de aplicar la proyección medio-axial (Proyección de Waters) como medio diagnóstico del hipo o hipertelorismo

Este estudio conduce a las conclusiones siguientes:

1. La sinusitis frontal puede tener lugar ya en el tercer año de la vida; así debe ser admitido habita cuenta del grado de neumatización observado en la revisión de placas obtenidas en el Hospital Infantil de Basilea durante los años 1961 y 1964.

2. La distancia interorbital parece ser un medio válido en el diagnóstico del hipo-hipertelorismo. Los valores obtenidos en la proyección medio-axial son comparables a las mediciones obtenidas en la proyección pósterio-anterior y aplicables de modo equiparable.

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Author's address: Dr. Gerald N. Siedband, St. Luke Hospital, 2900 West Oklahoma Avenue, Milwaukee, Wisconsin (USA).

Curriculum vitae

Am 21. September 1933 in Chicago, Illinois (USA), geboren, besuchte ich die Volksschule in Chicago und Venice High School in Venice, California. An der Roosevelt University (Chicago, Illinois, USA) erwarb ich das Diplom eines «Bachelor of Science» im September 1959. An der Universität Basel bestand ich im September 1961 das zweite propädeutische Examen. Das klinische Studium absolvierte ich in Basel und bestand das medizinische Staatsexamen am 1. Juni 1965.

